

## CLAIMS

What is claimed is:

- 1 1. A method for oxidizing a fuel, comprising:
  - 2 providing a catalyst mixture including at least one compound having at least one
  - 3 element selected from the group consisting of group III and group IIA, and
  - 4 at least one compound having at least one element selected from the group
  - 5 consisting of group IA, group IVA, group VI, group VII, group VIII,
  - 6 group IB, group IIB and combinations thereof;
  - 7 mixing a portion of the catalyst mixture with combustion air prior to mixing the
  - 8 catalyst mixture with a fuel to be oxidized; and
  - 9 oxidizing the fuel.
- 1 2. The method of claim 1, further comprising adding a liquid to the catalyst mixture
  - 2 before mixing it with the combustion air.
- 1 3. The method of claim 2, wherein the liquid comprises one or more liquids from the
  - 2 group consisting of ethylene glycol and water.
- 1 4. The method of claim 3, wherein the liquid further comprises lithium chloride.

1 5. The method of claim 1, further comprising sparging a gas through the catalyst  
2 mixture to generate fluidized catalyst particles to mix with the combustion air.

1 6. The method of claim 5, further comprising ionizing the sparging gas prior to  
2 sparging it through the catalyst mixture.

1 7. The method of claim 5, wherein the sparging gas is selected from the group  
2 consisting of air, helium, nitrogen, argon, and combinations thereof.

1 8. The method of claim 1, wherein the compound having a group III element is  
2 selected from the group consisting of  $\text{AlCl}_3$  and  $\text{Al}(\text{NO}_3)_3$ .

1 9. The method of claim 1, wherein the catalyst mixture comprises one or more of  
2 platinum, rhodium, rhenium, manganese, iron, aluminum, magnesium and  
3 molybdenum.

1 10. The method of claim 1, wherein oxidizing the fuel comprises oxidizing the fuel in  
2 an open flame.

- 1 11. The method of claim 1, wherein oxidizing the fuel comprises oxidizing the fuel in  
2 an enclosed flame.
- 1 12. The method of claim 1, wherein oxidizing the fuel comprises oxidizing gasoline.
- 1 13. The method of claim 1, wherein oxidizing the fuel comprises oxidizing diesel  
2 fuel.
- 1 14. The method of claim 1, wherein oxidizing the fuel comprises oxidizing a fuel  
2 selected from the group consisting of number 2 fuel oil, fuel oil refined from  
3 crude oil, diesel fuel, gasoline, compressed or liquified natural gas, gasohol, any  
4 hydrocarbon having one or more carbon atoms such as methane, ethane, propane,  
5 butane, isobutane, toluene, xylene, octane, benzene, mixtures of alcohols having  
6 methanol, ethanol, propanol, butanol, isopropanol, isobutanol, pentanol, hexanol,  
7 heptanol, octanol and combinations thereof, vegetable oil such as corn oil, mineral  
8 oil, coal, coal gas, asphalt vapor, oxidizable vapors from chemical processes,  
9 wood, paper and combinations thereof.
- 1 15. The method of claim 1, wherein oxidizing the fuel comprises oxidizing within a  
2 combustion chamber of a reciprocating engine selected from the group consisting  
3 of a gasoline fuel engine and a diesel fuel engine.

1 16. The method of claim 1, wherein oxidizing the fuel comprises oxidizing the fuel  
2 within a combustion chamber of a reciprocating engine, wherein the fuel is  
3 selected from the group consisting of number 2 fuel oil, fuel oil refined from  
4 crude oil, diesel fuel, gasoline, compressed or liquified natural gas, gasohol, any  
5 hydrocarbon having one or more carbon atoms such as methane, ethane, propane,  
6 butane, isobutane, toluene, xylene, octane, benzene, mixtures of alcohols having  
7 methanol, ethanol, propanol, butanol, isopropanol, isobutanol, pentanol, hexanol,  
8 heptanol, octanol and combinations thereof, vegetable oil such as corn oil, mineral  
9 oil, coal, coal gas, asphalt vapor, oxidizable vapors from chemical processes,  
10 wood, paper and combinations thereof.

1 17. The method of claim 1, wherein oxidizing the fuel comprises oxidizing within a  
2 flame zone of an apparatus selected from the group consisting of a furnace, a boiler  
3 and an incinerator.

1 18. The method of claim 1, wherein oxidizing the fuel further comprises oxidizing  
2 within an apparatus selected from the group consisting of an incinerator, a vent  
3 gas burner, a furnace, a steam turbine and combinations thereof.

1 19. The method of claim 1, wherein providing the catalyst mixture further comprises  
2 providing the catalyst mixture having a pH of less than about 4.0.

1 20. The method of claim 19, wherein providing the catalyst mixture further comprises  
2 providing the catalyst mixture having a pH of between about 1.4 and about 3.0.

1 21. The method of claim 20, wherein providing the catalyst mixture further comprises  
2 providing the catalyst mixture having a pH of between about 1.6 and about 2.2.

1 22. The method of claim 1, wherein the catalyst mixture comprises a concentration of  
2 Pt, as  $\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$  at least about 0.28 mg/ml, a concentration of Rh, as  $\text{RhCl}_3$  at  
3 least about 0.07 mg/ml, a concentration of Re, as perrhenic acid at least about 0.1  
4 mg/ml, and a concentration of Al, as  $\text{AlCl}_3$  at least about 0.07 mg/ml.

1 23. The method of claim 1, wherein the catalyst mixture comprises a concentration of  
2 Pt, as  $\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$  at least about 0.28 mg/ml, a concentration of Rh, as  $\text{RhCl}_3$  at  
3 least about 0.07 mg/ml, a concentration of Re, as perrhenic acid at least about 0.1  
4 mg/ml, and a concentration of Mg as  $\text{MgCl}_2$  at least about 0.07 mg/ml.

1 24. The method of claim 1, wherein the catalyst mixture further comprises a  
2 surfactant.

1 25. The method of claim 2, wherein the liquid further comprises a surfactant.

1 26. The method of claim 1, wherein mixing a portion of the catalyst with the  
2 combustion air comprises transporting the catalyst particles to a combustion air  
3 intake to the flame zone and mixing the catalyst with the combustion air within  
4 the air intake.

1 27. The method of claim 1, wherein a ratio of Pt to Rh in the mixture is between  
2 about 15 to 1 and about 4 to 1, a ratio of Pt to Re in the mixture is between about  
3 15 to 1 and about 2 to 1, and a ratio of Pt to Al in the mixture is between about 15  
4 to 1 and about 2 to 1.

1 28. The method of claim 24, wherein the ratio of Pt to Rh in the mixture is about 8.6  
2 to 1, the ratio of Pt to Re in the mixture is about 6 to 1, and the ratio of Pt to Al in  
3 the mixture is about 8.6 to 1.

1 29. A catalyst mixture for use in the generation of fluidized catalyst particles for fuel  
2 oxidation, the catalyst mixture comprising:  
3 at least one compound having at least one element selected from the group  
4 consisting of group III, group IIA and Lanthanide group; and  
5 at least one compound having at least one element selected from the group  
6 consisting of group IA, group IVA, group VI, group VII, group VIII,  
7 group IB, group IIB and combinations thereof.

1 30. The catalyst mixture of claim 29, wherein the catalyst mixture comprises a  
2 concentration of Pt, as  $\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$  at least about 0.28 mg/ml, a concentration of  
3 Rh, as  $\text{RhCl}_3$  at least about 0.07 mg/ml, a concentration of Re, as perrhenic acid at  
4 least about 0.1 mg/ml, and a concentration of Al, as  $\text{AlCl}_3$  at least about 0.07  
5 mg/ml.

1 31. The catalyst mixture of claim 29, wherein the catalyst mixture comprises a  
2 concentration of Pt, as  $\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$  at least about 0.28 mg/ml, a concentration of  
3 Rh, as  $\text{RhCl}_3$  at least about 0.07 mg/ml, a concentration of Re, as perrhenic acid at  
4 least about 0.1 mg/ml, and a concentration of Mg as  $\text{MgCl}_2$  at least about 0.07  
5 mg/ml.

1 32. The catalyst mixture of claim 29, wherein the catalyst mixture further comprises  
2 aqueous acid, wherein the catalyst mixture in aqueous acid has a pH of less than  
3 about 4.0.

1 33. The catalyst mixture of claim 32, wherein the aqueous acid is aqueous  
2 hydrochloric acid.

1 34. The catalyst mixture of claim 29, wherein the catalyst mixture in aqueous acid has  
2 a pH of between about 1.4 and about 3.0.

1 35. The catalyst mixture of claim 29, wherein the catalyst mixture in aqueous acid has  
2 a pH of between about 1.6 and about 2.2.

1 36. The catalyst mixture of claim 29, further comprising a liquid comprising  
2 substantially equal parts of ethylene glycol and water.

1 37. The catalyst mixture of claim 35, further comprising one or more of LiCl, NaCl,  
2 and HCl.



1 38. The catalyst mixture of claim 29, wherein the catalyst mixture further comprises a  
2 surfactant selected from the group consisting of ethylene glycol, propylene glycol,  
3 methanol, ethanol, propanol, butanol, pentanol, hexanol, isopropyl alcohol, isobutyl  
4 alcohol, silicone oil, and combinations thereof.

1 39. The catalyst mixture of claim 29, wherein a ratio of Pt to Rh in the mixture is  
2 between about 15 to 1 and about 4 to 1, a ratio of Pt to Re in the mixture is  
3 between about 15 to 1 and about 2 to 1, and a ratio of Pt to Al in the mixture is  
4 between about 15 to 1 and about 2 to 1.

1 40. The catalyst mixture of claim 39, wherein the ratio of Pt to Rh in the mixture is  
2 about 8.6 to 1, the ratio of Pt to Re in the mixture is about 6 to 1, and the ratio of  
3 Pt to Al in the mixture is about 8.6 to 1.

- 1 41. A fuel oxidation system comprising:  
2 a flame zone for oxidizing fuel;  
3 a catalyst chamber having a catalyst mixture therein, the catalyst mixture  
4 comprising:  
5 at least one compound having at least one element selected from the group  
6 consisting of group III and group IIA; and  
7 at least one compound having at least one element selected from the group  
8 consisting of group IA, group IVA, group VI, group VII, group  
9 VIII, group IB, group II and combinations thereof; and  
10 a catalyst transport configured to transport catalyst particles from the catalyst  
11 chamber to the flame zone.
- 1 42. The system of claim 41, wherein the flame zone is that of an open flame.
- 1 43. The system of claim 41, wherein the flame zone is that of an enclosed flame.
- 1 44. The system of claim 41, wherein the system is configured to oxidize a fuel  
2 selected from the group consisting of gasoline and diesel fuel.

1 45. The system of claim 41, wherein the system is configured to oxidize a fuel  
2 selected from the group consisting of number 2 fuel oil, fuel oil refined from  
3 crude oil, diesel fuel, gasoline, compressed or liquified natural gas, gasohol, any  
4 hydrocarbon having one or more carbon atoms such as methane, ethane, propane,  
5 butane, isobutane, toluene, xylene, octane, benzene, mixtures of alcohols having  
6 methanol, ethanol, propanol, butanol, isopropanol, isobutanol, pentanol, hexanol,  
7 heptanol, octanol and combinations thereof, vegetable oil such as corn oil, mineral  
8 oil, coal, coal gas, asphalt vapor, oxidizable vapors from chemical processes,  
9 wood, paper and combinations thereof.

1 46. The system of claim 41, wherein the flame zone is a combustion chamber of a  
2 reciprocating engine selected from the group consisting of a gasoline fuel engine  
3 and a diesel fuel engine.

1 47. The system of claim 41, wherein the flame zone is a combustion chamber of a  
2 reciprocating engine configured to oxidize a fuel is selected from the group

1 consisting of number 2 fuel oil, fuel oil refined from crude oil, diesel fuel,  
2 gasoline, compressed or liquified natural gas, gasohol, any hydrocarbon having  
3 one or more carbon atoms such as methane, ethane, propane, butane, isobutane,  
4 toluene, xylene, octane, benzene, mixtures of alcohols having methanol, ethanol,  
5 propanol, butanol, isopropanol, isobutanol, pentanol, hexanol, heptanol, octanol  
6 and combinations thereof, vegetable oil such as corn oil, mineral oil, coal, coal  
7 gas, asphalt vapor, oxidizable vapors from chemical processes, wood, paper and  
8 combinations thereof.

1 48. The system of claim 41, wherein oxidizing the fuel comprises oxidizing within a  
2 flame zone of an apparatus selected from the group consisting of a furnace, a boiler  
3 and an incinerator.

- 1 50. A method of oxidizing fuel, the method comprising:  
2 sparging a gas through a catalyst mixture comprising at least one Platinum  
3 compound and at least one compound containing at least one of Aluminum  
4 and Magnesium;  
5 mixing catalyst mixture particles with combustion air prior to adding fuel; and  
6 oxidizing fuel in the presence of the catalyst-containing combustion air.
- 1 51. The method of claim 50, wherein the sparging gas is selected from the group  
2 consisting of helium, argon, nitrogen, air and combinations thereof.
- 1 52. The method of claim 50, further comprising ionizing the sparging gas prior to  
2 sparging it through the catalyst mixture.
- 1 53. The method of claim 50, further comprising transporting the particles to a flame  
2 zone under negative pressure.
- 1 54. The method of claim 50, further comprising establishing a catalyst mixture having  
2 a pH of less than about 4.0 prior to sparging the gas through the catalyst mixture.

1 55. The method of claim 50, further comprising establishing a catalyst mixture having  
2 a pH of between about 1.4 and about 3.0 prior to sparging the gas through the  
3 catalyst mixture.

1 56. A catalyst mixture for oxidation of a fuel, the catalyst mixture comprising:  
2 about 0.24 mg/ml of  $\text{H}_2\text{PtCl}_6 \cdot 6\text{H}_2\text{O}$ ;  
3 about 0.28 mg/ml of  $\text{RhCl}_3$ ;  
4 about 0.4 mg/ml of  $\text{HReO}_4$ ; and  
5 between about 0.28 mg/ml and about 0.56 mg/ml of at least one of  $\text{AlCl}_3$  and  
6  $\text{MgCl}_2$ .

1 57. The catalyst mixture of claim 56, wherein a ratio of Pt to Rh in the mixture is  
2 between about 15 to 1 and about 4 to 1, a ratio of Pt to Re in the mixture is  
3 between about 15 to 1 and about 2 to 1, and a ratio of Pt to Al or Mg in the  
4 mixture is between about 15 to 1 and about 2 to 1.

1 58. The catalyst mixture of claim 57, wherein the ratio of Pt to Rh in the mixture is  
2 about 8.6 to 1, the ratio of Pt to Re in the mixture is about 6 to 1, and the ratio of  
3 Pt to Al or Mg in the mixture is about 8.6 to 1.

1 59. The catalyst mixture of claim 56, wherein the total volume of the catalyst mixture  
2 is about 650 ml.

1 53. The catalyst mixture of claim 51, the liquid further comprising one or more of  
2 HCl, NaCl, and LiCl.

1 54. The catalyst mixture of claim 53, wherein the liquid comprises approximately  
2 5400 ppm of LiCl by weight.

1 55. The catalyst mixture of claim 49, further comprising hydrochloric acid.

1 56. The catalyst mixture of claim 49, wherein the catalyst mixture has a pH of less  
2 than about 4.0.

1 57. The catalyst mixture of claim 49, wherein the catalyst mixture has a pH of  
2 between about 1.2 and about 4.0.

1 58. The catalyst mixture of claim 49, wherein the catalyst mixture has a pH of  
2 between about 1.4 and about 3.0.

1 59. The catalyst mixture of claim 49, wherein the catalyst mixture has a pH of  
2 between about 1.6 and about 2.2.

1 60. The catalyst mixture of claim 49, wherein the catalyst mixture further comprises a  
2 surfactant selected from the group consisting of ethylene glycol, propylene glycol,  
3 methanol, ethanol, propanol, butanol, pentanol, hexanol, isopropyl alcohol, isobutyl  
4 alcohol, silicone oil, and combinations thereof.

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